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ECONOMIC BENEFITS OF COAL TRANSSHIPMENT
FACILITIES FOR SMALL USERS

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Introduction

Declining natural gas supplies and uncertainty over future oil supplies have led to a Federal energy policy of encouraging increased coal use. Administration policies have so far been confined to direct orders requiring electric generating stations and very large industrial plants to use coal. However, financial incentives to reduce the high capital costs required to convert from gas to oil to coal have also received wide discussion.

On the other hand, action to encourage conversion to coal by reducing its delivered cost has recieved relatively little attention. This is surprising, as annual coal costs will greatly exceed the amortized capital cost of coal conversion at a typical installation. Cost of coal at the mine may not be the most important consideration in reducing delivered coal prices. For example, in Minnesota the transportion and related handling costs of coal are usually greater than the price of coal at the mine.

This paper will examine the extent to which delivered coal prices in southern and central Minnesota (Figure 1) could be reduced if a more efficient coal distribution system was established for potential users.

Most of the coal used in Minnesota arrives from the West in either unit train, volume train, multiple car or single car shipments. The Eastern coal that Minnesota uses is delivered mainly by barge and lake vessel. Currently, many of the larger coal users receive their shipments directly either by unit or volume train or by barge.[1/] This means that the coal is delivered track-side or dock-side to their plant or that short-distance secondary transport is involved. However, the smaller users must in many

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[1/] One barge holds the same amount of coal as fourteen large rail cars (1400 tons).

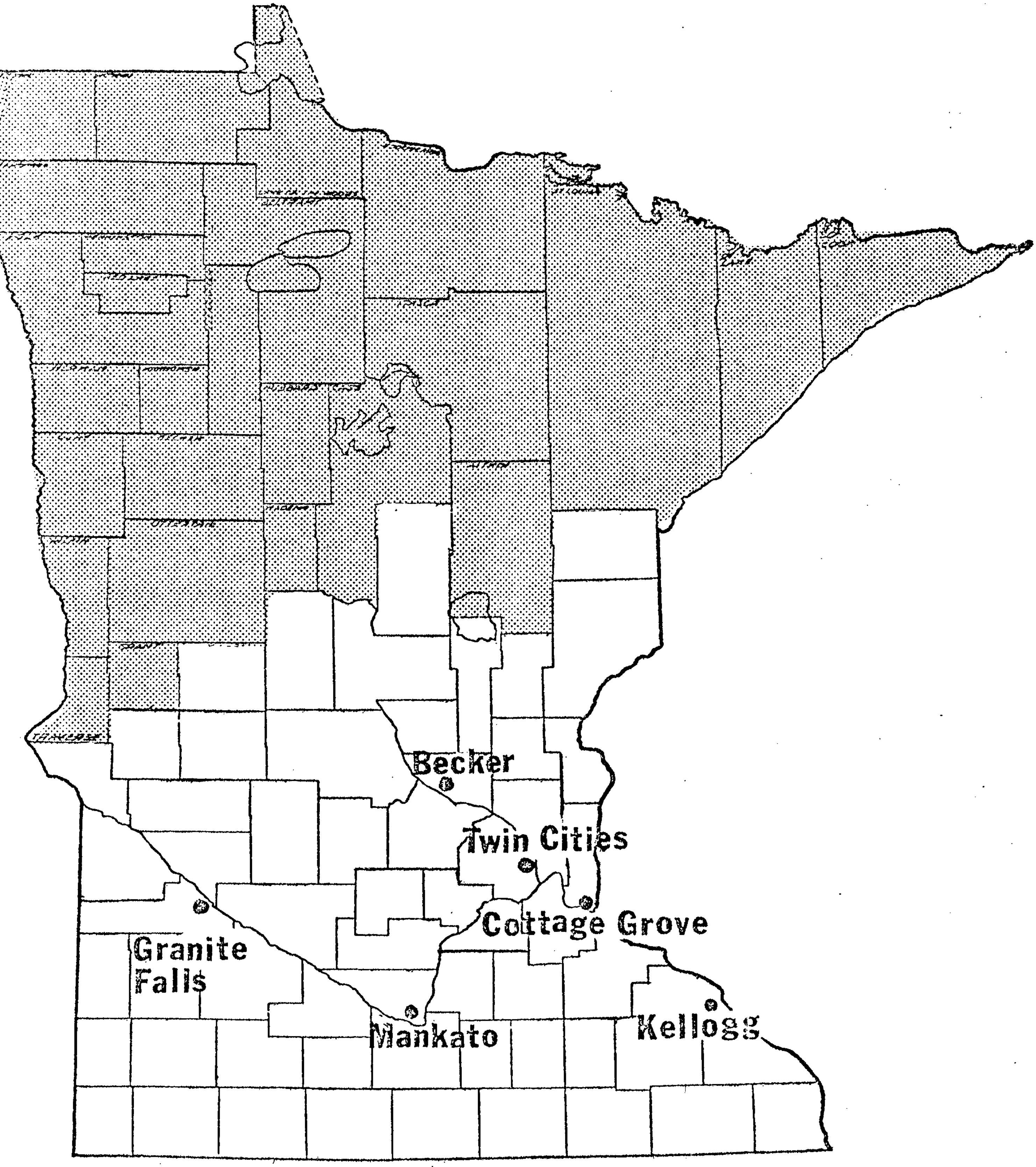

Figure 1. Map of Minnesota Study Area (unshaded) Showing Twin Cities and Five Possible Coal Terminal Sites.

cases receive their coal supplies by single (rail) car or truck which involve greater per unit transportation rates.

This study will examine locating coal handling terminals throughout the state whose use will not be limited to a single user. By having this type of terminal available, the small user of coal can capitalize on the economic advantage of unit train and barge rates relative to single and multiple car and truck rates. Also, since many existing oil and natural gas users may switch to coal if the economic incentive is there, increased conservation of oil and natural gas will be a favorable by-product. The question is then: Could a planned grid of public transshipment sites in central and southern Minnesota benefit current and future coal users in lower total transportation and handling cost relative to the existing distribution system? This paper will examine that question.

Coal Use and Distribution in the Study Area

Coal use in southern Minnesota is currently 4.7 million tons per year. Most of the coal is used by a small number of electrical generating plants. The 1985 coal use in the study area could grow to 15.7 million tons annually when natural gas is curtailed to some 300 industrial and commercial users who now rely on oil or propane as an alternative fuel. Of the potential 1985 demand, 13.6 million tons are already committed. The remaining 2.1 million tons are the potential coal use by the 300 natural gas users who must decide among fuel oil, propane and coal as their gas supplies are curtailed.

Most of the coal currently used in southern Minnesota is from the Powder River Basin in Montana and Wyoming or from southern Illinois and western Kentucky. Coal from eastern sources has been declining in relative importance, primarily because of its high sulfur content and relatively high price. The analyses in this paper assumes that the trend to western coal will continue and that new coal users will be supplied by mines in Montana and Wyoming.

Virtually all of the coal leaving Montana and Wyoming moves by rail. Many large-volume natural gas and petroleum customers cannot receive fuel by rail and would have to take delivery by truck if they converted to coal. However, existing coal terminals in the Twin Cities area with train-to-truck transloading capabilities are operating at or near their permitted capacities. Without expansion in terminal capacity, this group of potential coal customers cannot convert to coal no matter what financial incentives they may be offered.

Most of the potential coal customers who can receive coal by rail face high rail rates since their individual coal consumption is too low for them to qualify for volume rates. The trainload and unit train[1/] rates to Minnesota are 50 to 60 percent of the single car or 15 car rates. Major savings are available to shippers who have access to such rates. In fact, the difference in cost between the single car and unit train rate may be greater than the cost of the coal at the mine.

The breakdown in the price of delivered coal to Minneapolis-St. Paul for 1977 and 1979 is shown in Figures 2 and 3 respectively. For single car

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[1/] A unit train is a dedicated set of locomotives and cars that remain together from origin to destination and travel at relative high speeds. Time requirements for loading and unloading are minimal. Major operating and administrative efficiencies are obtained. Trainload shipments provide similar, though smaller, savings.

shipments transportation costs account for 62% of the delivered price in 1977 and 66% in 1979. Unit train shipments are substantially less in 1977 at 46% but increased to 55% in 1979. For longer shipments such as those from the Powder River Basin to Texas these transportation costs account for even greater shares of the delivered price.

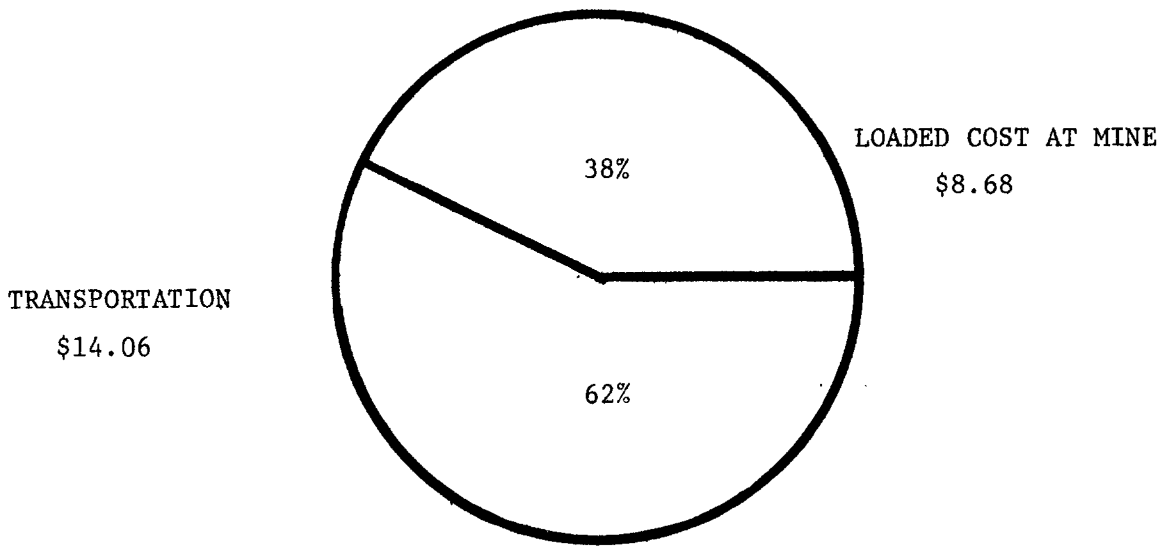
Transshipping Terminals

A central coal terminal serving several smaller users could conceivably generate sufficient volume to qualify for unit train rates. However, a substantial investment in high speed unloading equipment is required in order to take advantage of the unit train concept. The minimum capital cost of a facility that can handle unit trains, and store and transship or process a single grade of coal approaches $8 million. Fruin and Crnkovich (May 1978) have estimated the minimum capital cost of a rail to truck transshipping facility that can receive, process and store several grades of coal to be $10 million.[1/]

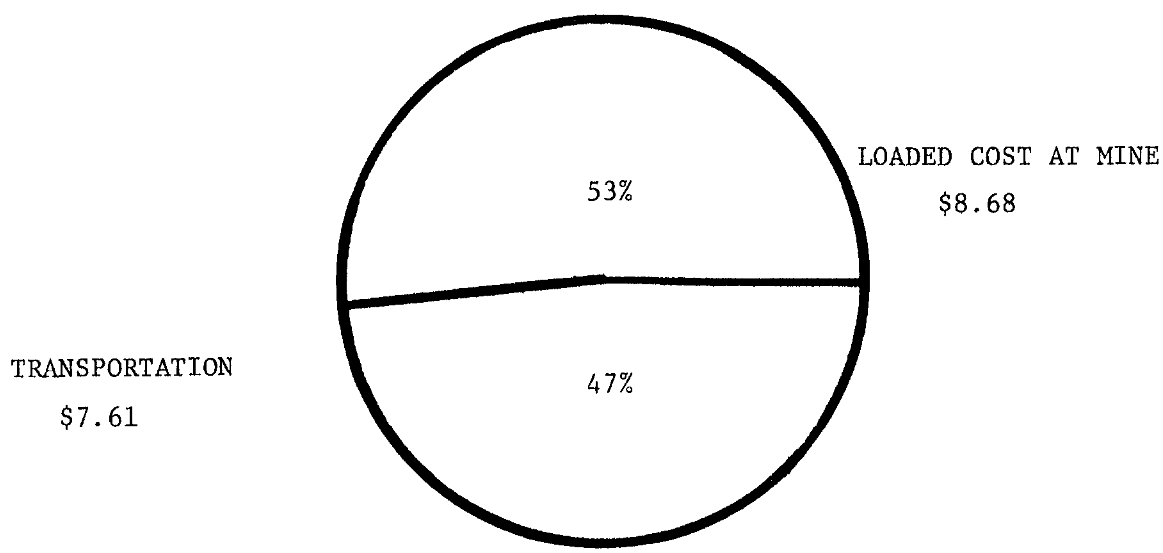
Delivery from such a terminal would eliminate the difficulty faced by those customers who cannot receive coal by rail. For coal users who can receive rail shipments, trucking from a central terminal may in many cases be less expensive than paying single car rail rates for direct shipments from the mines.

[1/] The minimum capital cost of transshipping facilities with both rail-to-truck and rail-to-water was estimated at 12 to 15 million dollars.

Figure 2. Components of Delivered Coal, Colstrip to Minneapolis-St. Paul July 1977-June 1978

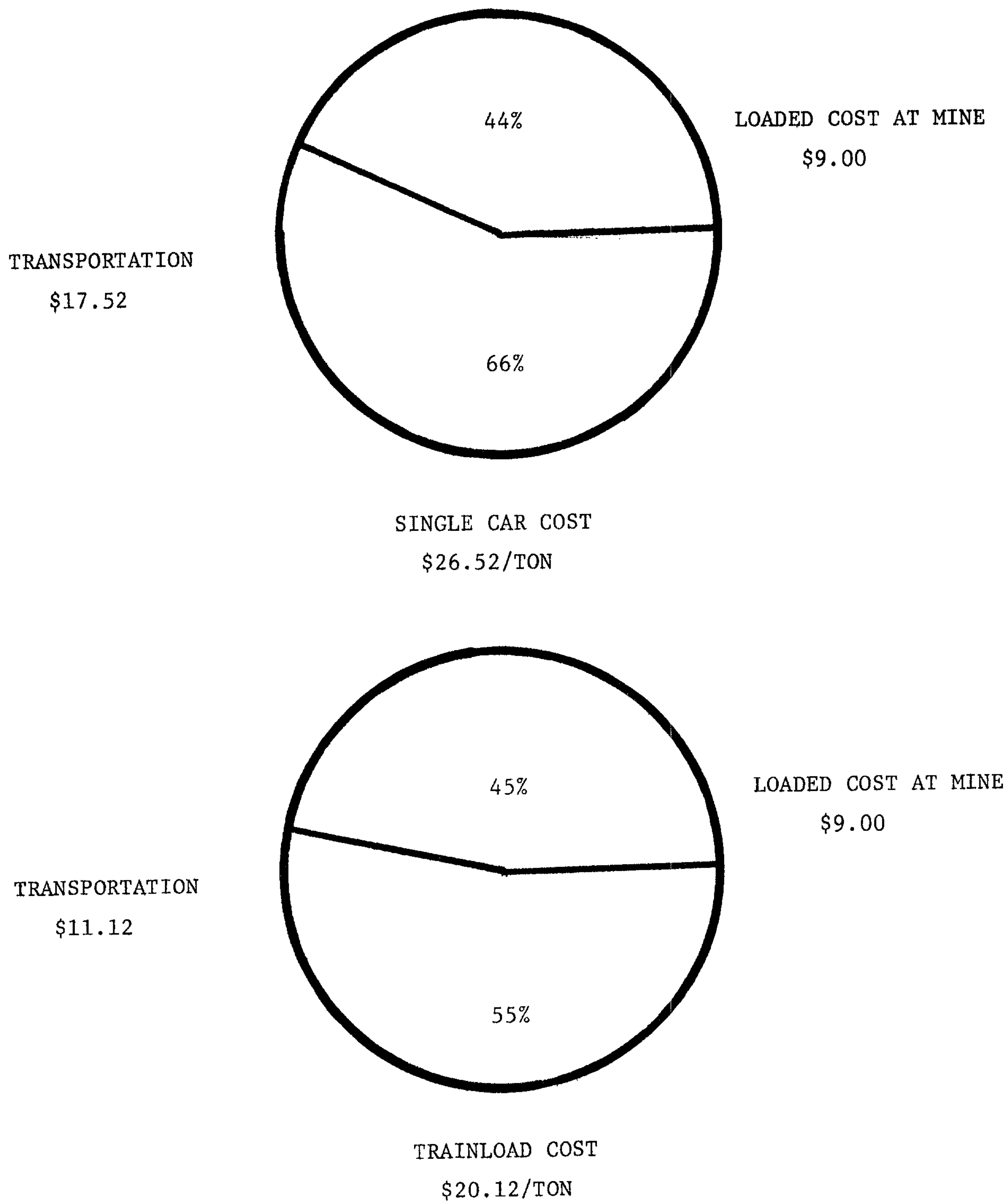


SINGLE CAR COST
22.74/TON



TRAINLOAD COST
$16.29/TON

Figure 3. Cost Components of Delivered Coal, Colstrip to Minneapolis-St. Paul
October 1, 1979



Data Description

The northwestern part of Minnesota contains a number of large coal users. However, because of its proximity to the North Dakota lignite supply, it warrants a separate analysis and is not included here. Also, although the western coal use in the Iron Range district is significant, the majority of that demand will be from a few industrial and utility users. The road network and terrain make it likely that truck costs on the Iron Range are higher. For these reasons and also to reduce complexity, this paper will limit its analysis to central and southern Minnesota coal users. The transshipment model area is shown in Figure 1.

Five sites were selected as possible locations for rail-to-truck coal transshipping terminals (see Figure 1). Becker was chosen since a large coal-fired electric generating station with unit-train unloading capabilities is already located there. With additional investment of approximately 2 million for equipment the existing terminal could serve smaller customers as well as the power plant. Three of the other sites, Granite Falls, Mankato and Kellogg, are possible locations for new coal-fired electric generating plants. Terminals could be designed to serve both the power plants and other users. The final site, Cottage Grove, was selected because it is close to the concentrated industrial areas of the Twin Cities and has been proposed as a potential terminal site.

Ninety-eight demand points were specified throughout central and southern Minnesota. Demand points were selected based on locations of present and potential industrial coal users. At least one demand point was located in each county with existing or potential coal use. The total 1985 coal demand of all consumers was projected to be 4.3 million tons per year.1/ Of this, 2.2 million tons per year was accounted for by "committed" users, i.e., those that are either now using coal or have definite plans to convert. The remaining 2.1 million tons per year is the potential demand if all industrial natural gas customers in the area converted to coal. Initial model runs assumed that all of the potential demand would be realized; this assumption was modified in later runs to allow for situations with less than 100 percent conversion to coal. Location of each user and estimated 1985 coal use was considered. Mileages between the Western coal supply source (assumed to be Colstrip, Montana) and points in Minnesota were found in a railroad atlas [2]. Mileages between points in Minnesota were obtained from the highway mileage tables [3]. Rail, barge, and truck rates were obtained from a University of Minnesota, Department of Agricultural and Applied Economics publication [4].

Procedure

The cost implications of a Minnesota transshipment system were examined by use of a linear programming transshipment analysis using the Control Data Corporation APEX-I linear programming system [5]. Linear programming can be used to minimize coal transportation and handling costs subject to a set of constraints setting the maximum amount of coal that will be shipped out of the Colstrip mine to Minnesota, accounting for coal shipped directly to transloading sites and then to individual demand points, and insuring that all relevant coal demands are satisfied.

1/An additional 11.4 million tons per year of the area's projected 1985 coal demand is accounted for by five large power plants. These plants are large enough to receive high volume rail shipments directly from the mines and would not need a new terminal. Therefore, their coal demand was not included in the analysis.

The linear programming analysis described here consisted of a series of computer runs. The first run is described as the "baseline case" and assumed that in 1985 all the relevant demand points in southern and central Minnesota are receiving their coal directly from Colstrip, Montana by single or multiple car rail shipments depending on the size of the user's requirements. In other words, there are no public transshipment sites in this model.

The following set of runs (Phase I) assumed that each transshipping site included in a run would handle at least 3,000,000 tons of coal per year at an average transshipping cost 77¢ per ton or less. As will be seen later, this is an important assumption as transshipping costs and site location are very sensitive to annual volume. This assumption of 3,000,000 tons per year can be justified if the transfer facility is located at a major power plant or barge loading facility. Becker currently is a power plant site, Mankato, Kellogg and Granite Falls are proposed sites and Cottage Grove is the proposed site for a barge loading facility.

A subsequent set of runs (Phase II) relaxed this requirement of 3,000,000 tons volume per years. The procedure was then iterated until the transshipping cost was appropriate for the volume going to small users.

Results Baseline and Phase I

The initial run was for the baseline, i.e., all direct shipments, model. The total estimated coal transportation cost for this baseline model is $57,029,530. There were 98 corresponding demand points (40 of which were committed 1985 users) that received 4,297,176 tons of coal by rail.

The next computer runs assumed one public transshipment site. The computer run for a single transshipping facility at Cottage Grove indicated that 1,169,980 tons of coal would be shipped directly by rail to 30 demand points, but that 68 demand points would receive 3,127,196 tons of coal via the Cottage Grove transloading terminal. This transshipment model represented a 17.87 percent improvement in total transportation and handling cost over the baseline case. The distribution area that would be served by a single transshipping site at Cottage Grove is shown in Figure 4.

A similar computer run assumed a single transshipping site at Becker. This site served 46 demand points but had a volume of only 980,278 tons of coal. Direct shipments went to 52 sites with total volume of 3,316,898 tons. Savings were on 3.79 percent of the baseline cost. Figure 5 shows the service of a single site at Becker. Similar runs were made for the other three sites which indicated savings of 5.5 to 6.9 percent over the baseline case.

The next step was made assuming two coal transshipping sites. One model assumed two coal transshipment sites located at Cottage Grove and Becker. In this model, 1,023,134 tons of coal is shipped direct to 22 demand points. There are 24 demand points receiving 460,236 tons of coal via the Becker terminal and 52 demand points receiving 2,813,570 tons via the Cottage Grove facility. The service areas for each transshipping point are shown in Figure 6. This possible transshipment network represents a 19.10 percent decrease in total transportation and handling cost over the baseline case. This was the most favorable of models with 2 transshipping sites. For example, transshipping facilities at Becker and Kellogg would provide a savings of 8.36 percent over the baseline case or less than one-half that of Cottage Grove alone.

The next set of runs considered locating three transshipping sites in southern Minnesota. E.g., transshipment sites were located at Cottage Grove, Becker and Granite Falls. The respective figures of coal transshipped are

FIGURE 4. Service Area for the Transshipment Points of Cottage Grove

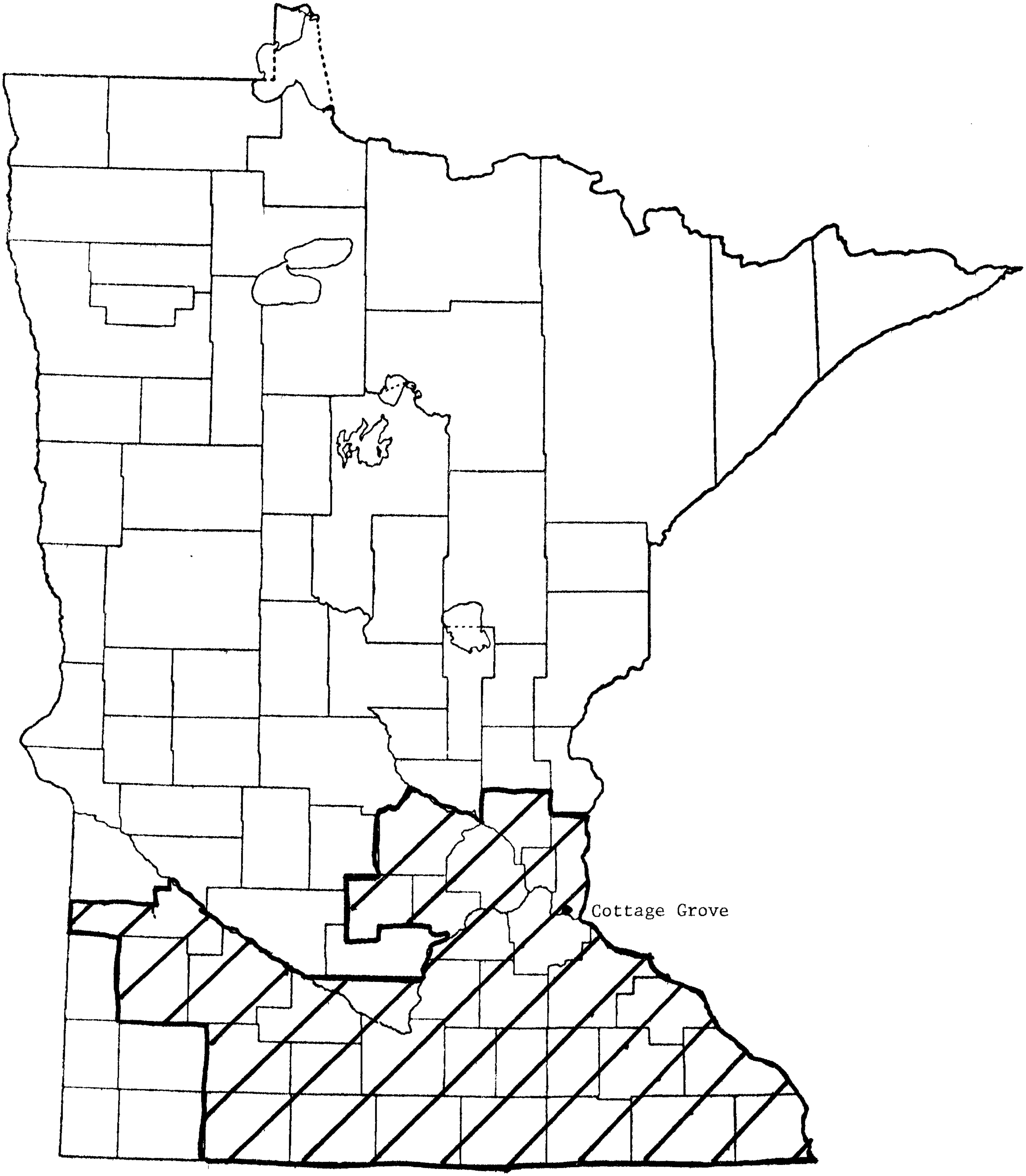


Figure 5. Service Areas for Transshipment Points of Becker

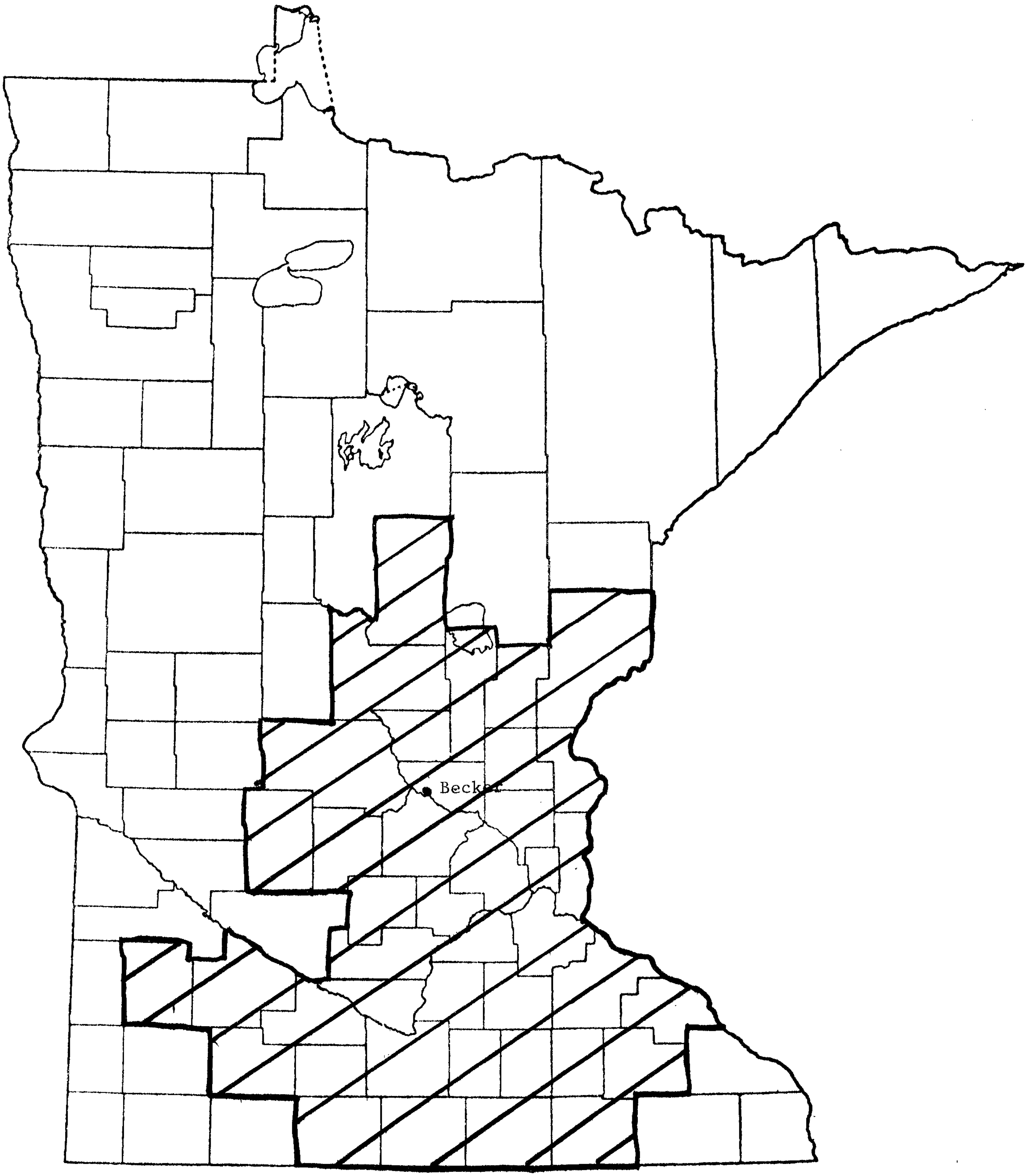
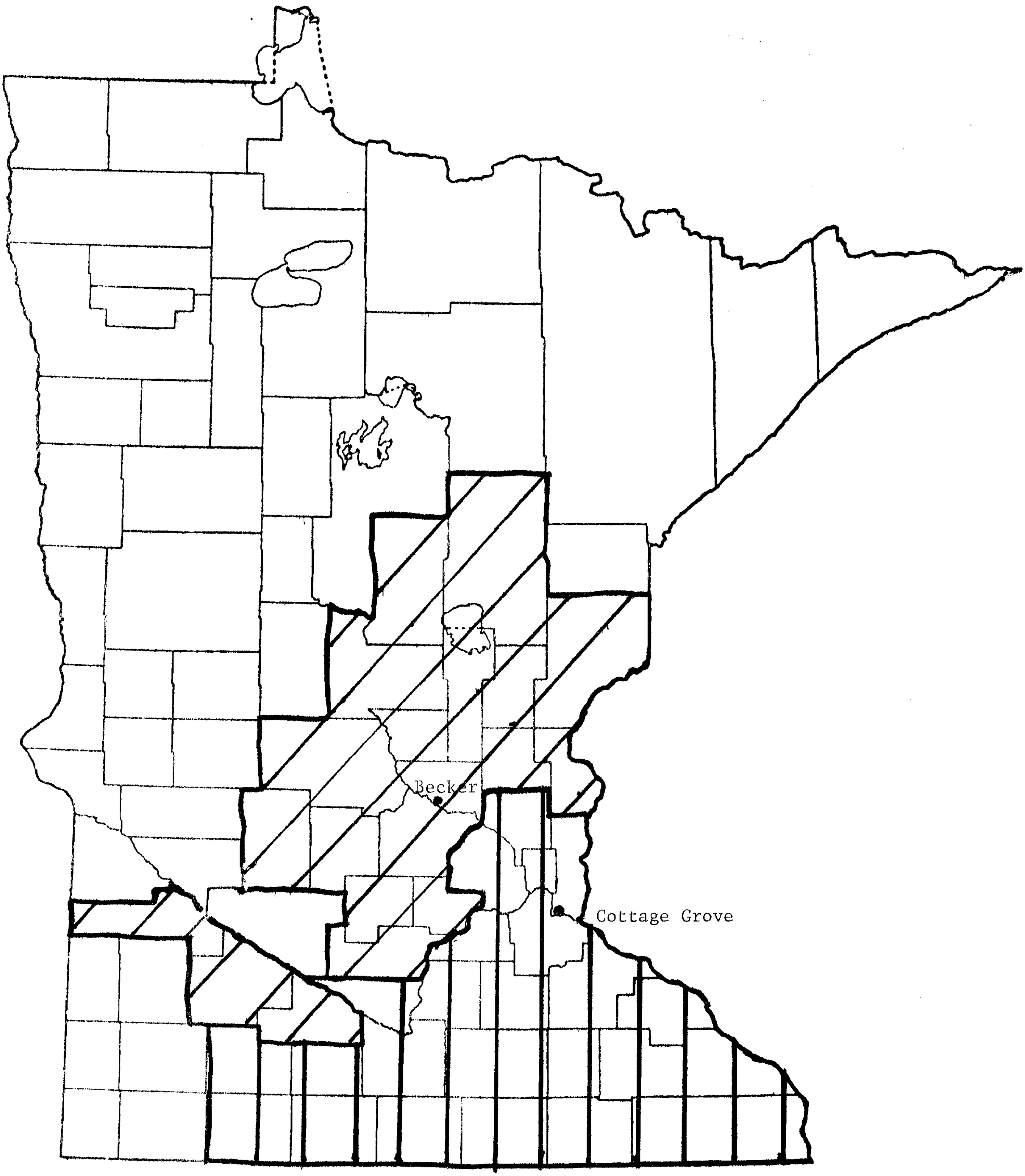


FIGURE 6. Service Area for Transshipment Points of Cottage Grove and Becker



2,729,533 tons to 45 locations, 243,573 tons to 15 locations, and 948,611 tons to 31 locations. The service areas for these transshipping points are shown in Figure 7. This transshipment network indicated the greatest reduction in transportation and handling cost over the adjusted baseline case, namely 22.55 percent, but only represents a further savings of 3.45% over the two transshipping terminal models with Becker and Cottage Grove. Further analysis included 3 terminal models with both Mankato and Kellogg being combined separately with Cottage Grove and Becker. These two models along with the others discussed are summarized in Table 1.

Savings of as much as 17.9 percent of coal transportation and handling costs can be obtained by a single transshipping facility in a well selected location in Cottage Grove. Savings of over 19 percent and 22.5 percent can be obtained with 2 or 3 such facilities.[1/] On the other hand, a single transshipping facility at Becker would provide savings of under 4 percent even though it is located near the relatively dense market area of the Twin Cities.

Results - Phase II

The above results are based on the fundatmental assumptions that the transloading cost at any of the above terminals is $0.77 per ton of coal transloaded. This is based on costs for a transloading facility with a 3,000,000 ton a year throughput with around the clock operation. This would result in a low estimate of the transloading costs for several of

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[1/] A total of 16 different site groupings were analyzed. With the exception of a single site at Becker, those reported are the most advantageous site groupings.

FIGURE 7. Service Area for Transshipment Points of Cottage Grove, Becker, and Granite Falls

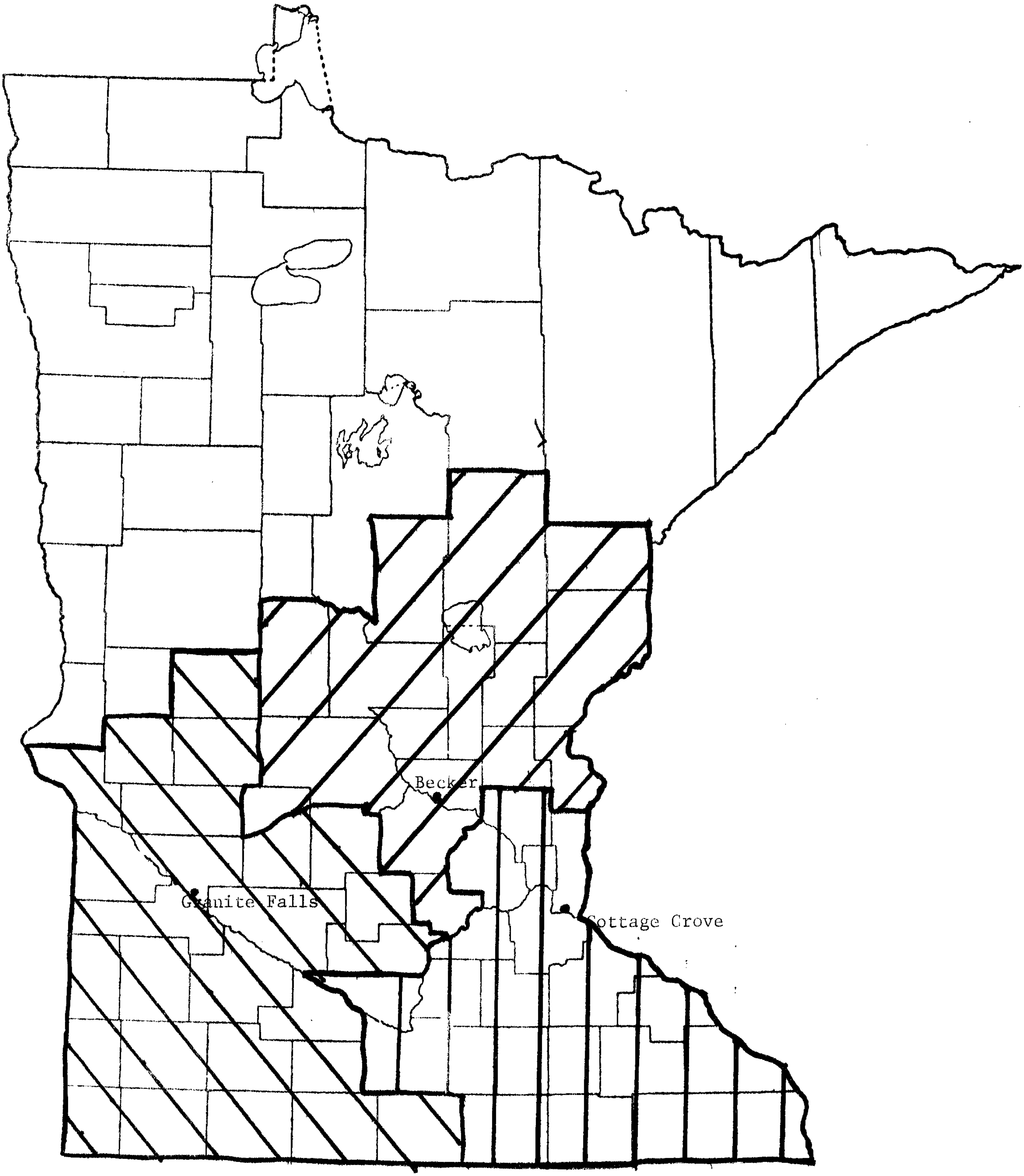

Table 1. Total Shipments and Savings for Selected Transshipping Alternatives (Power Plants or Barge Terminal at all Locations)

Transshipping Points	Total Shipments (tons)	Savings Over Baseline (dollars)	(percent)
None (Baseline)	--		
Direct from mines	4,297,176	--	--
Becker	980,278	2,160,000	3.79
Direct from mine	3,316,898		
Cottage Grove	3,127,196	10,188,677	17.87
Direct from mine	1,169,980		
Becker	460,236		
Cottage Grove	2,813,570	10,892,170	19.10
Direct from mine	1,023,370		
Becker	460,236		
Cottage Grove	2,167,335	11,394,000	19.98
Kellogg	646,215		
Direct from mine	1,023,370		
Becker	332,203		
Cottage Grove	2,491,674	12,469,000	21.86
Mankato	436,283		
Direct from mine	880,801		
Becker	243,573		
Cottage Grove	2,729,533	12,862,000	22.55
Granite Falls	948,611		
Direct from mine	375,459		

the above models if a coal-fired power plant or a barge loading facility did not exist at the transshipping site (e.g. Granite Falls, Mankato or Kellogg). If a coal-fired power plant existed at those locations, the additional coal demand would justify an approximate transloading cost of $0.77 per ton. However, if power plants did not exist at those locations the transloading costs would be much higher. As can be seen from Table 2, a more accurate transloading cost for handling the 948,611 tons at a Granite Falls site would be approximately $1.95 per ton. Similarly, $3.70 per ton and $2.60 per ton would correspond to the 436,283 tons and 646,215 tons handled by Mankato and Kellogg respectively in Phase I.

In Phase II the transshipping costs were increased on successive runs until they corresponded to the volume levels going through the terminals. This exercise clearly showed the sensitivity of the solutions to the baseload volume (and operating cost per ton) of the transshipping facility. The two solutions judged to have economic viability are shown in Table 3.

The least-cost solution (assuming no new power plants) was obtained with a combination of the Becker and Cottage Grove sites. Total transportation and handling charges with these transshipping facilities were 18.9 percent lower than the $57 million baseline case. For Cottage Grove, the relatively low transshipping charge of $.81/ton was due to the large amount of coal being transshipped through the terminal. In contrast, the low transshipping charge at Becker ($.73/ton) was due to the existing power plant. Even though only 460,000 tons of coal were transshipped to other users from Becker, in excess of 3.2 million tons per year are transhipped for use in electrical generation at Becker.

Table 2. Estimates of Rail to Truck Coal Transshipping Costs for Selected Annual Volumes (1978)

Terminal Throughput	Fixed Cost[a/]	Variable Costs	Total Transshipping Costs
(1,000 tons per year)			($/ton)
400	3.30	.53	3.83
800	1.65	.48	2.13
1200	1.10	.48	1.58
1600	.82	.39	1.21
2000	.66	.38	1.04
2400	.55	.34	.89
2800	.47	.34	.81
3200 or more	.41	.32	.73

[a/] A $10,000,000 transshipping facility fully amortized over a 20 year period using an 8 percent interest rate. Property taxes and insurance were estimated at 3 percent of the capital costs.

Source: Fruin and Crnkovich (May 1978).

The relative importance of the Becker and Cottage Grove sites in the least-cost solution can be seen by comparing that solution with one including only the Cottage Grove site. Although the marginal savings due to adding the Becker site are relatively small, there are significant advantages for using the site at a terminal. The majority of the transshipping facilities are already present because of the power plant. Construction of the additional facilities for the terminal were estimated to cost $2,000,000. The simple payback period based on the $1,000,000 savings would be only two years. Furthermore, truck traffic from the terminals would originate from two sites rather than one, thereby partially alleviating a potentially serious traffic problem.

The remaining alternative in Table 3 includes Granite Falls along with Cottage Grove and Becker. The savings increases only 1.63% or about $1 million. Only 325,977 tons is transshipped because of the lower density of coal users in that part of the state. Without the power plant there a transshipping charge of $2.13 must be charged. Mankato and Kellogg when added to Becker and Cottage Grove separately transship less than Granite Falls does and the savings is small.

Phase III

In each of the above solutions, it was assumed that all committed and potential users would use coal. It is very unlikely that all of the potential users will use coal. The high costs involved in converting heating and energy systems to coal, environmental restrictions on coal use in certain areas, and discoveries of new natural gas supplies could all

Table 3. Total Shipment and Savings for Selected Transshipping Alternatives (No New Power Plants) (1977)

Transshipping Points	Total Shipments	Savings Over Baseline[1/]	
	(tons)	(dollars)	(percent)
None (Baseline)			
Direct from Mines	4,297,176	---	---
Cottage Grove[2/]	3,127,196	10,095,000	17.70
Direct from Mines	1,169,980		
Becker[3/]	460,836		
Cottage Grove[2/]	2,812,970	10,780,272	18.90
Direct from Mines	1,023,370		
Becker	489,764		
Cottage Grove	2,742,366	11,707,996	20.53
Granite Falls	325,977		
Baseline	739,069		

[1/]Total baseline costs for direct shipments of 4,297,176 tons of coal were $57,029,533.

[2/]Transshipping rate interpolated from Table 2.

[3/]Becker is an existing power plant site and was assigned a transshipping rate of $.73 for this phase of the analysis.

discourage maximum coal conversion. In any case, some potential users would find conversion unprofitable or environmentally impossible and would continue with their present secondary fuel even as the costs for such fuels rise.

To demonstrate the effect of only some of the users coverting to coal, the total demand for each potential user was cut in half for a subsequent series of runs. The total reduction in coal demand was only 1.1 million tons, or 25 percent of the total amount, since the demand by the committed users was not affected. The least-cost solution of the reduced demand model was the same as before, Becker and Cottage Grove. The total savings over the baseline case were, of course, less because less coal was shipped. However, savings of $6.6 million per year were still possible with this case, as compared to savings of $10.8 million per year in the full-demand model. The Becker terminal, which retained the same transshipping charge as before because of the power plant, reduced its throughput by only 16 percent, even though overall coal transshipped to small users was reduced by 25 percent. In contrast, the Cottage Grove site reduced its throughput amount by 35 percent because there was no "baseload" demand by a power plant to guarantee a large throughput and low transshipping charges.

Phase II 1979 Data

The next step in the analysis was to update the cost of transporting coal to the final demand point. All rail rates and truck rates were taken from recent tariffs. The transshipping charges were figured by applying the construction and labor indices to the respected cost estimates for the construction and operation of a terminal. The total cost of the capital requirements for a terminal increased 11.16% while labor costs increased approximately 12.0%. These new updated transshipping charges are shown in Table 4.

This updated model then was run again similar to Phase II. The total transportation cost of the baseline case was $69,583,070. Table 5 details the results of these runs. The same terminal combinations were used. The comparison between 1977 and 1978 are shown in Table 6. As one can see from Table 6 a significant decline can be seen in the savings of the operation of a terminal. An average of approximately 680,000 tons is shipped directly rather than through a terminal between 1977 and 1979. An average loss of savings of 40% is found by all alternatives listed between the same period. The savings, though, is still enough to realize the advantage of the terminal. Each alternative in Table 6 still shows at least a $7 million savings over the baseline.

The difference in rates for shipping coal between 1977 and 1979 can be seen in Table 7. Rate differences are shown for unit and single car rail rates along with truck rates. Unit train rates have increased much faster than those for single car rates. This fact lessens the desirability of the terminal because the single car direct shipments become more competitive with the terminal. Truck rates generally increase at the same amount as single car rates. This demonstrates that the increase in total transportation costs is mostly due to the increase in unit train rates to the terminal site.

Summary and Conclusions

1. Recent changes in the western coal rate structure relationships have substantially reduced the economic savings that can be obtained using coal

Table 4. Estimates of Rail to Truck Coal Transshipping Costs for Selected Annual Volumes (1979)

Terminal Throughput	Fixed Costs	Variable Costs	Total T.C.
400	3.80	.48	4.28
800	1.90	.48	2.38
1200	1.28	.48	1.76
1600	.96	.39	1.35
2000	.77	.39	1.16
2400	.64	.34	.98
2800	.56	.35	.91

Source: Fruin and Crnkovich (May 1978) updated data.

Table 5. Total Shipments and Savings for Selected Transshipping Alternatives (No New Power Plants) (1979)

Transshipping Points	Total Shipments	Savings Over Baselines	
	(tons)	(dollars)	(percent)
None (Baseline)			
Direct from Mines	4,297,176	---	---
Cottage Grove	2,385,527		
Direct from Mines	1,911,649	7,127,635	10.24
Becker	687,961		
Cottage Grove	1,966,872		
Direct from Mines	1,642,343	7,621,174	10.95
Becker	325,038		
Cottage Grove	2,050,633	8,697,093	12.50
Granite Falls	497,748		
Direct from Mines	1,423,757		

Table 6. Comparison of Shipments and Savings 1977-1979

Transshipping Points	Total Shipments		% Δ in Shipments		Savings Over Baseline (percent)		% Δ in Savings
	1977	1979	1977	1979	1977	1979	
Cottage Grove	3,127,196	2,385,527	-23.72				
Direct from Mine	1,169,980	1,911,649	63.39		17.15	10.24	-40.29
Becker	460,836	687,961	49.29				
Cottage Grove	2,812,970	1,966,872	-30.08				
Direct from Mine	1,023,370	1,642,343	60.48		18.90	10.95	-42.06
Becker	489,764	325,038	-33.63				
Cottage Grove	2,742,366	2,050,633	-25.22				
Granite Falls	325,977	497,748	52.69				
Direct from Mine	739,069	1,423,757	92.64		20.53	12.50	-39.11

Table 7. Rate Increases 1977 to March 1979 for Rail and Truck

Origin	Destination	1977	1979	% Increase
Unit Train				
Colstrip	Becker	6.07	8.89	46.46
Colstrip	Cohasset	5.82	10.09	73.37
Becker	Superior	6.55	9.82	49.92
Single Car				
Colstrip	Duluth	13.61	16.20	19.03
Colstrip	Twin Cities	14.06	16.73	18.99
Colstrip	Rochester	15.56	18.52	19.02
Truck				
Duluth	Bemidji	5.53	6.84	23.69
Becker[1/]	Carver Co.	3.60	4.30	19.44
Cottage Grove[1/]	Brown Co.	7.48	8.30	10.96

[1/] Estimated rates from Minnesota Public Service Commission Tariff #9.

Source: BN tariff and Minnesota Public Service Commission truck tariffs.

distribution centers. Possible dollar savings under optimum conditions using 1979 rates are approximately 40% less than those possible under the 1977 rate structure.

2. Substantial savings for coal users in southern Minnesota can be obtained through gains in efficiency in coal transportation and distribution. Savings exceeding $8.6 million or 12.5 percent of transportation and handling costs at 1979 rates would be possible if:

   a. Coal transshipping facilities were constructed at Becker, Cottage Grove and a third location in conjunction with a new power plant in southern Minnesota.
   b. All potential users convert to coal.
   c. All potential and committed users use western coal.

3. Savings exceeding $7.1 million or 10.2 percent of the total coal transportation and handling costs at 1979 rates could be obtained if:

   a. A coal transshipping facility was optimally located in the Twin Cities metro area where coal demand is concentrated.
   b. All potential users in the service area of that transshipping facility convert to coal.
   c. All potential and committed users use western coal.

4. From a system efficiency standpoint it would be advantageous to add public transshipping facilities at the existing power plant at Becker under the above assumptions. Ways to divide the cost savings between the owners of the power plant and small shippers were not considered nor were any institutional constraints such as existing charters, contracts or regulations.

5. With the exception of the Twin Cities area, it does not appear feasible to encourage construction of large coal transshipping facilities unless they are on the site of large (2 million tons or more) coal users.

6. In the future, the power plant site selection process should consider the suitability of the proposed location as a coal transshipping location and when appropriate, a condition of the granting permit should require the development of a public transfer facility.

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